

**UNIVERSITI TEKNOLOGI MARA**

**INVESTIGATION ON PHASES  
TRANSFORMATION AND  
MECHANICAL PROPERTIES OF  
DUCTILE IRON BY NEW HEAT  
TREATMENT PROCESS**

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Thesis submitted in fulfillment  
of the requirements for the degree of  
**Master of Science**

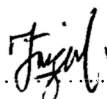
**Faculty of Mechanical Engineering**

**September 2013**

## **AUTHOR'S DECLARATION**

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non- academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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## ABSTRACT

This study was conducted to investigate quantitatively and qualitatively the matrix compositions and transformations, and to evaluate the correlation between microstructure constituent and material hardness on each sequential stage of new heat treatment process at different temperatures. In addition, the influence of new heat treatment temperature on impact and tensile properties is analyzed. Ductile iron produced by CO<sub>2</sub> sand casting method was heat treated by new heat treatment cycle that comprised combination of modified annealing, austenitizing and tempering processes. The new heat treatment process performed was divided into three stages: first stage consists of modified annealing (as-annealed condition); second stage consists of modified annealing and austenitizing processes (as-austenitized condition); and third stage consists of modified annealing, austenitizing and tempering processes (as-tempered condition). A series of microstructure analysis tests, including optical microscopy, X-ray diffractometry, and scanning electron microscopy equipped with energy dispersive X-ray, was applied. Mechanical tests including tensile (ASTM E8M), impact toughness (ASTM-E23-1990) and Vickers hardness test were performed. The results suggest that heat treatment temperature influences the matrix and volume fraction of each phase of ductile iron. Annealing included in new heat treatment process does influence the hardness of ductile iron. Moreover, microstructure constituents have good correlation with mechanical properties. It is proven that, hardness could be estimated using mixture law of hardness for each microstructure constituent. Tensile strength and hardness of ductile iron decrease with decreasing volume fraction of martensite. Increasing ferrite volume fraction results an increasing impact toughness and elongation. The ductile iron treated using this practice is corresponds and equipotential with ADI 'grade 1' (ASTM standard A897-90).

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